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MELBOURNE, VICTORIA

Aircraft Systems Technical Memorandum 141

A DEMONSTRATION OF AN AIRCRAFT NAVIGATOR'S MOVING MAP DISPLAY

by

D.A. CRAVEN

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A DEMONSTRATION OF AN AIRCRAFT NAVIGATOR'S MOVING MAP DISPLAY

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SUMMARY

A demonstrator version of a low-cost Moving Map Display has been developed. The display has been oriented towards use as a navigator's aid in maritime patrol aircraft operations.

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1. INTRODUCTION

In the P3-C maritime patrol aircraft, the navigator is responsible for many communications related tasks while airborne, and as a result cannot afford to spend excessive time on his navigational duties. The concept of a low-cost Moving Map Display (MMD) as a navigator's aid has been proposed in order to minimise the time involved in assessing the aircraft's situation and identifying any deviations from the required course.The display should convey the aircraft's position, track and course (by means of pre-determined waypoints) superimposed on a map. It is required to be easily readable and involve minimal operator effort.

A demonstrator of such a navigator's display has been developed and is incorporated into Flight Management Group's Programmable Cockpit*. Aircraft position, track and waypoint information are received via an RS232 serial line. Operator control of the display is by a touch sensitive screen. Two map representations have been included in the demonstrator : a simple coast-only map (labelled "Digital") onto which other features may be added in the future; and a more conventional digitised paper map (labelled "Paper").

Since this display is intended for the navigator's station, north-up orientation of the map is sufficient. This simplifies the hardware requirements considerably as, unlike pilot-oriented heading-up displays, no image rotation is involved.

2. MOVING MAP DISPLAY FEATURES

The default screen format is as appears in Figure 1. The display shows a map with an aircraft symbol at the centre of the screen. The aircraft's current position is indicated by the brightly coloured vertex of this symbol (not apparent in the black and white illustrations). Emanating from this point is the aircraft's track line; the path the aircraft will traverse if conditions remain unchanged.

Figure 1 : 1:250K coastline only map

* The Programmable Cockpit is a multi-computer system which is used for research into cockpit layouts (Refs. 1 - 5). It currently consists of four closely arranged screens onto which different cockpit instruments can be displayed, all driven from a common aircraft model. This provides a test-bed for determining the effectiveness of new or modified instruments, as they can be assessed in an environment simulating the cockpit as a whole.

The left and top edges of the screen show latitude and longitude corresponding to the gridlines on the map. Up to three waypoints or markers along the course can be displayed (nominally the "From" ($\boxed{F}$), "To" ($\boxed{T}$) and "Following" ($\boxed{}$) waypoints) and these are shown in Figure 1 joined by a straight line course. The bottom edge of the display shows two touch-screen "switches", involved in selecting map parameters, separated by a caption reflecting the current selection. The right-hand switch initiates scale changes for the digital map. At present, 1:250K and 1:500K (Figure 2) scales are supported.

Figure 2 : 1:500K coastline only map

The left switch is concerned with the type of map, and changes the display between its "Digital" (rendered from coastline data) and "Paper" (digitised paper map - Figure 3) modes. Scale change is not supported for the "Paper" map.

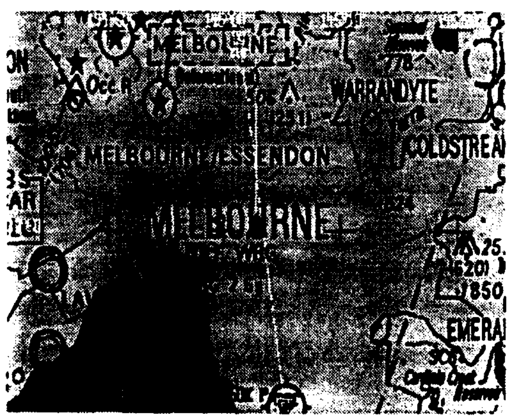


Figure 3 : 1:250K digitised paper map

Pressing the top right-hand corner of the display causes a menu of display options to appear (Figure 4). These allow some portions of the display to be masked out if circumstances lead it to appear cluttered.

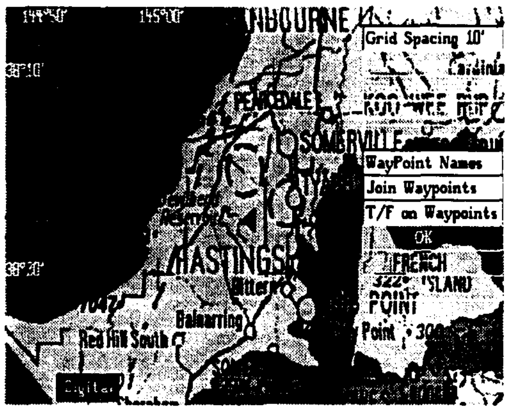


Figure 4 - Menu

The options include :

Grid Spacing	: selectable between 10, 20, 30 and 60 minutes;
WayPoint Names	: to inhibit/display names given to waypoints;
T/F on Waypoints	: to inhibit/display the labelling of the "To" waypoint with a "T" and the "From" waypoint with an "F"

Join Waypoints : to inhibit/display a straight-line path between the "From", "To" and "Following" waypoints respectively.

3. HARDWARE

The major requirements of the graphics system are:

- the ability to move regions of the display quickly, so as to facilitate generation of a moving map;
- a non-destructive overlay mechanism, so that a change in aircraft situation or waypoint selection etc. does not require complete regeneration of the map; and
- low level support for quickly filling (colouring in) areas of the graphics display in order to efficiently produce land/sea representations from coastline data.

The Commodore Amiga, having a capable graphics co-processor chip set that meets these requirements, was chosen as an economical base for the demonstrator. It has been fitted with a touch-screen to detect operator input.

3.1 Display Organisation

The picture seen on the screen is a combination of two separate layers in memory : the foreground, into which the aircraft symbol, waypoint information, and gridscales are rendered; and the background, where the map is drawn (Figure 5). Each layer consists of an image defined by two bit-planes, allowing four colours for the background and three for the overlay (since colour zero is interpreted as being transparent). The Amiga's graphics hardware supports this setup directly in its "Dual Playfield" mode (Ref. 6). This mode also allows the freedom of having different sized layers that may be scrolled independently. Both layers use double-buffering techniques which allow a new image to be constructed off-screen without disrupting the display. As a result, screen changes appear to be instantaneous.

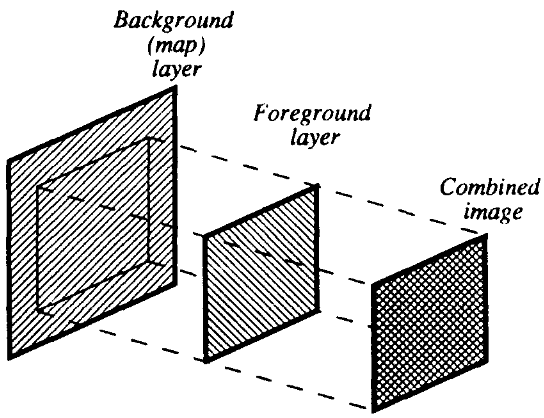


Figure 5 : Structure of display memory

The background layer also utilises the concept of a "super" bit-map (Ref. 7), meaning the rendered image is much larger than can be seen on the display. The screen only shows a "window" into this area centred around a point corresponding to the aircraft's current position. (The screen's resolution allows the display of 640 x 256 pixels, while the map is "drawn" to video memory on an area of 1024 x 480 pixels.) As a result, small movements in the aircraft's position only require the starting point of the window to be re-defined rather than generation of a new map.

The foreground screen, however, does have to be updated for each such movement. The Amiga chip-set includes a blitter (block image transferrer) that is capable of transferring large blocks of display memory to different locations without involving the 68000 processor. The recycling of pre-rendered images by using the blitter to "cut and paste" into the foreground layer's alternate buffer, as well as the relative simplicity of this layer, minimise the overhead involved in regenerating the display.

4.SOFTWARE

The program was written in Modula-2 with embedded assembly code being used for speed critical routines and patching into standard C libraries. Appendices 1 and 2 show flow charts for the two main processes : the high priority MMD I/O task, which updates the display whenever new data is available; and the low priority Update Map task, which constructs a new map image off-screen when necessary (§4.3).

4.1 Digital Coastline Representation

Data for the map is stored as separately addressable sections, each representing an area corresponding to one eighth of a degree square. The coastline in this area is recorded as a number of contours, each representing a continuous line segment (Figure 6).

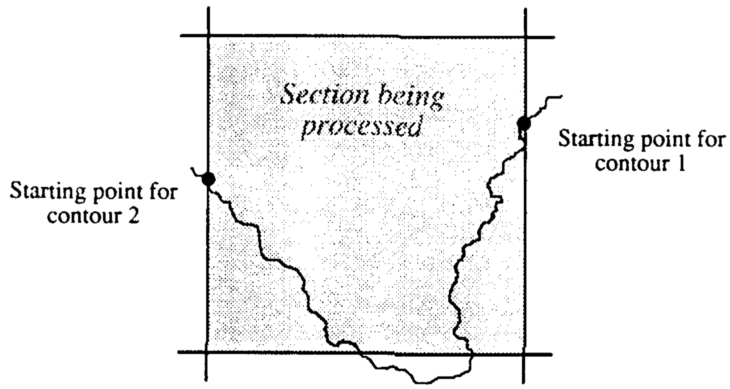


Figure 6 : Map section with two contours

For each contour, the starting point (relative to the north-west corner of the section) and the number of points defining it are stored. The contour is then built up from a list of entries that represent the direction (relative to the current point) to move the drawing position before plotting the next point (Figure 7). Since the contour is destined for a bit-mapped display, where any pixel has a maximum of eight neighbouring pixels, only three bits (representing directions zero to seven) are used for each point.

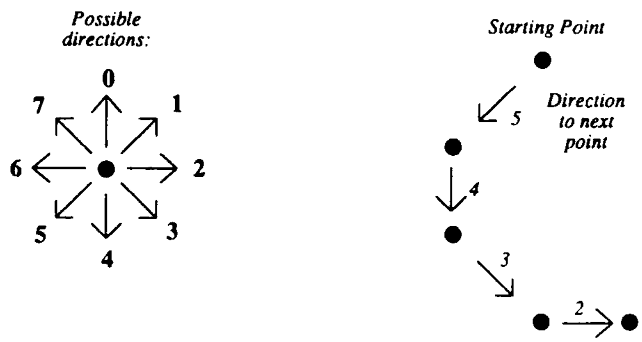


Figure 7 : Example of coastline construction

The database contains entries for each section as follows :

Starting state (land or water)	1	bit	
Number of contours (nC)	7	bits	
X starting coordinate for contour n	8	bits	repeated for nC contours
Y starting coordinate for contour n	8	bits	
Number of points in contour n (nP)	16	bits	
Vector data - relative direction to next point	3	bits	
:			
relative direction to point nP	3	bits	
Pad to byte boundary	0-7	bits	

Sections without any land/water interfaces only use one byte of storage, being the starting state (whether this block is land or water) and the number of contours (zero). A separate program, MapEditor, has been written to interactively produce and change the database under mouse control.

In order to take advantage of the Amiga's ability to perform hardware raster fills, the coastline must be drawn into the bitmap in a "compatible" manner. The fill operation scans the image one line at a time, and switches on or off the fill whenever it crosses an active pixel (Figure 8). As such, the coastline has to be rendered so that each point plotted represents a horizontal land/water transition in the bitmap. The software drawing the background image only plots those points satisfying this requirement, and makes alterations necessary for singular points (local minima/maxima) which would lead to "bleeding" along their associated scan-lines.

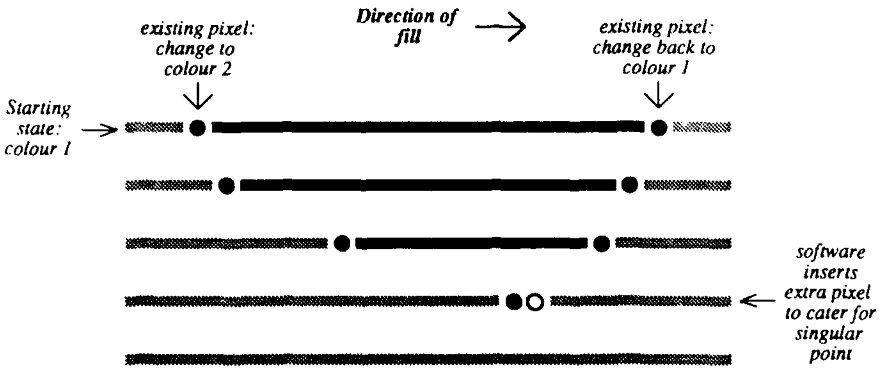


Figure 8 : Raster fill operation

The raw data covering the southern Victorian region (used for demonstration with the Programmable Cockpit) produces a 1:250K scale coastline when displayed on the screen. However, the same data can easily be used to produce smaller scales, as can be seen in the 1:500K case. At present, the coastline is the only information stored in the database, although it could be expanded to include other information that may be displayed / inhibited as required.

4.2 Digitised Paper Map Representation

The paper map displayed was constructed using Digi-View, a video digitiser specific to the Amiga. To facilitate compatibility with software controlling the digital map, the database was also constructed to use one-eighth of a degree square sections, and the image was digitised to represent a 1:250K scale.

Scaling this type of map is not practical as any loss in detail makes features such as place names appear unreadable. Although this map displays much more information than the coast-only map, it gives an overall impression of appearing cluttered as none of the information is maskable. Another disadvantage is the comparatively large size of the digitised database.

4.3 Map Management

Software controlling the map monitors the position of the visible window relative to the greater image held in display memory. When it is apparent that there is danger of the window approaching an edge of this image, a background task is activated to update the map. This involves salvaging the portion of the map still likely to be needed by copying it to the second buffer region (Figure 9). The Amiga's block image transferrer is used in this process, and a considerable time saving is achieved as a significant portion of the updated map is effectively pre-drawn.

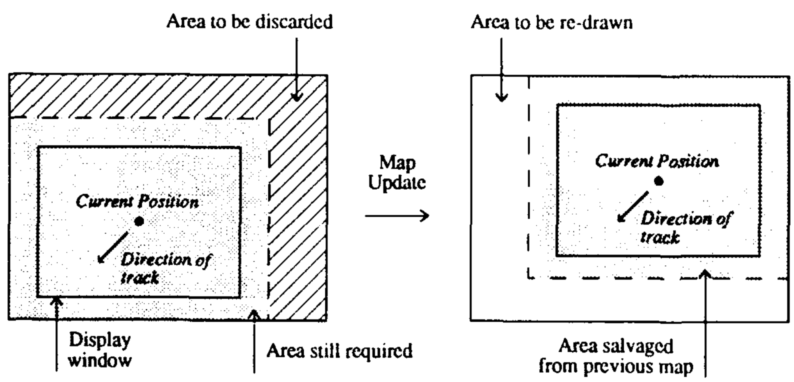


Figure 9 : Updating the map

The display is then modified to use this buffer, while the remainder of the area (still out of view) is rendered from the map database in the otherwise idle time between aircraft data updates. The aircraft position etc. is continually being updated during this process, and by the time any of these "new" areas are visible on the screen they have safely been rendered. As a result, no discontinuities in movement can be detected by the operator.

4.4 Aircraft Data Requirements

The MMD uses the following entities from the Programmable Cockpit's data stream:

NPosition, EPosition	: the North and East displacements, used for calculating the current latitude/longitude;
Heading, DriftAngle	: used to produce the aircraft's track line;
FromWPN, FromWPE, NameFrom, *ToWPN, ToWPE, NameTo,* *FollWPN, FollWPE NameFoll*	: used for the display of waypoint information.

All other information is ignored.

4.5 Storage Requirements

The digital coastline map is by far the most efficient in terms of memory requirements. The entire coastline of Australia would require around 100 Kilobytes of storage. The paper map, if digitised to cover only the same coastal area, would require in excess of 10 Megabytes of storage (100 times the requirement of the digital coastline version).

4.6 Modifications Required for Airborne Use

In order to enable installation into an aircraft, the demonstrator would need the following modifications:

• The program and data-base (currently stored on disk) would need to be transferred to a more robust device - e.g. Read Only Memory;

• An interface to the aircraft's data bus would be required. Flight Management Group have developed (for another application) a unit which selectively reads data from the LTN-72 INS (as used in the P3C). This could be adapted for the MMD;

• A smaller screen (depending on available space) may need to be incorporated:

• The touch screen may need to be replaced with a programmable soft-keys if the screen size makes it difficult to use;

• A power supply, providing +12, -12 and +5 volts (as well as power for the screen) would need to be built: and

• Ruggedized housing for the computer, power supply and data interface would be required.

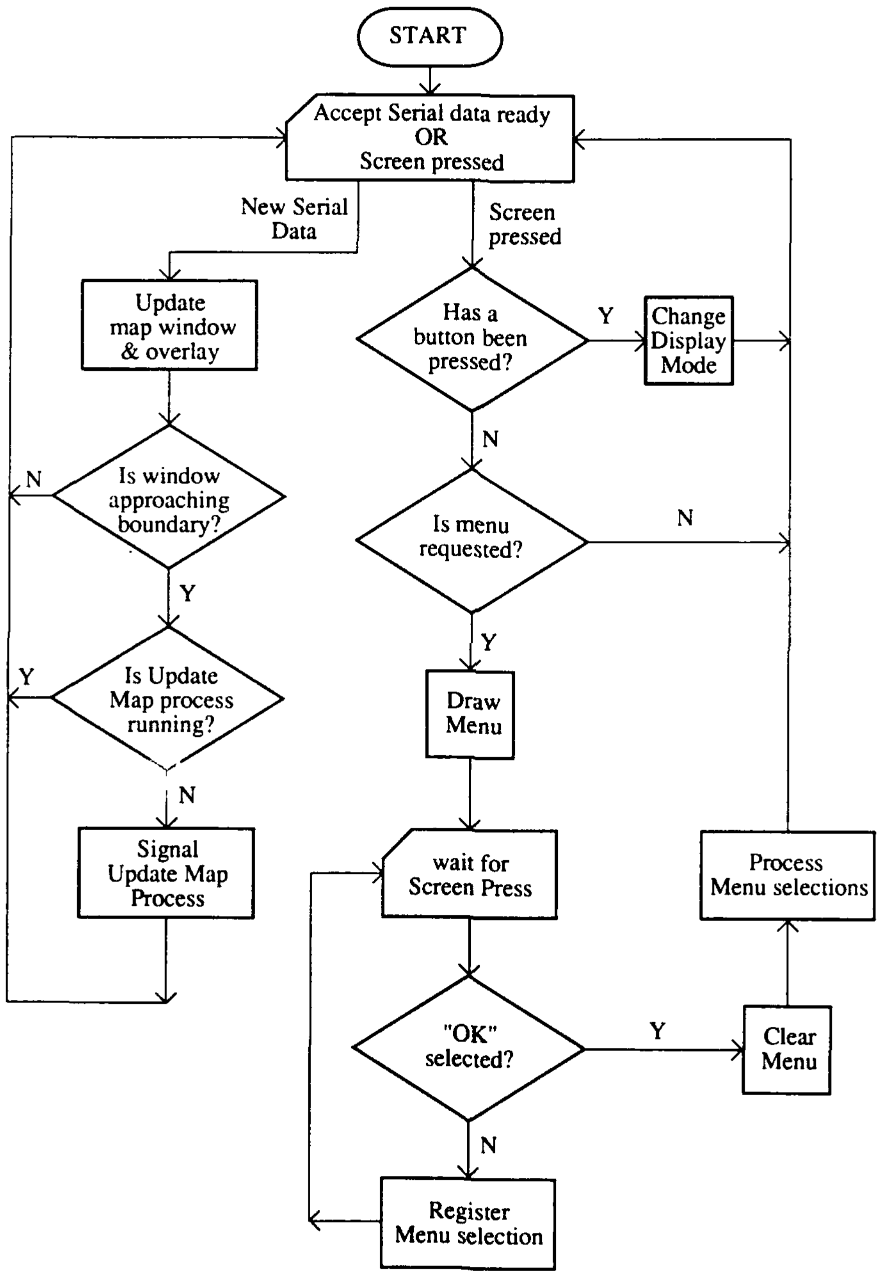
5. CONCLUDING REMARKS

A demonstrator of a navigator oriented, low-cost Moving Map Display has been produced using a Commodore Amiga as the host system. The instrument has been incorporated in the Programmable Cockpit and proves effective in communicating course information in a clear, uncomplicated manner. Although not intended as a pilot aid, it does prove useful in demonstrating other navigational instruments in the cockpit; it allows the user to more easily relate the instrument indications to where the aircraft is actually heading.

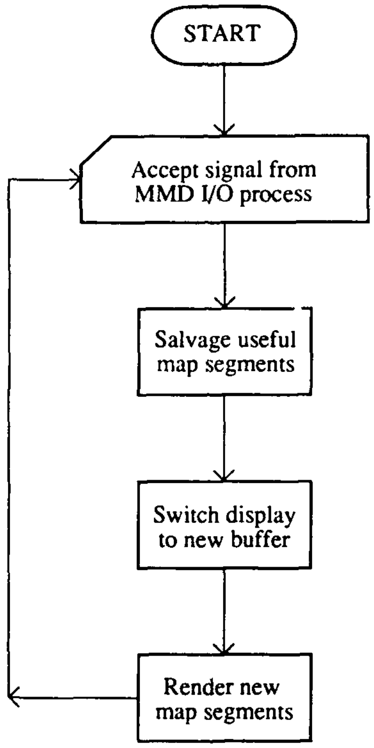
The concept could be extended to incorporate other desirable features specific to an aircraft or installation. Possible further developments of the display include :

- Entry of waypoints via the touch-screen;
- The ability to store, recall and display a library of standard waypoints and navaids;
- The inclusion of terrain elevation data, where shading of land regions could be used to indicate height information; and
- The display of safe height information, where threatening terrain could be indicated by having a different colour.

APPENDIX 1 : HSD I/O Process Flow Chart



APPENDIX 2 : HSD Update Map Process Flow Chart



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